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Effect of the Incorporation Level of Ripe Avocado Pulp Powder *Persea americana* on the Zootechnical Performances of *Clarias jaensis* Juveniles (Boulanger, 1909)

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Abstract:

In order to contribute to the valorization of agricultural by-products in fish feed, the effect of the incorporation level of the ripe avocado pulp powder *persea americana* on the zootechnical performance of *Clarias jaensis* Juveniles (Boulanger, 1909), was studied between February and July 2019 in the highland zone of West Cameroon. To attend the aims, 156 juvenile *Clarias jaensis* (25.82 ± 7.43g) settled in triplicates in floating tanks were fed four iso-protein rations (40% crude protein) corresponding to 0, 8, 12 and 16% incorporation of ripe avocado. Feed were distributed twice daily (8 am and 6 pm) at 5% of the fish biomass for 63 days. The following results were as follows: Survival rate, final mean weight, daily mean weight gain, specific growth rate and condition factor K were higher and non-significant in batches receiving 8% of ripe avocado pulp powder with a lower feed conversion ratio (99,14 ± 0,50% ; 40,22 ± 10,5g; 0,14 ± 0,44 g/d, 0,41 ± 1,07 %g/d; 0,70 ± 0,09 %g/cm^3 and 1,87 ± 0,09) and lower with a highest feed conversion ratio at 16% incorporation (93,67 ± 8,47 %; 30,02 ± 8,00g; 0,08 ± 0,22 g/d; 0,28 ± 0,77 % g /d; 0,68 ± 0,15 %g/cm^3 and 2,018 ± 017). Body composition varied with the level of pulp meal incorporation, water content was high with 0% (79.14%), and dry matter (23.87%), crude protein (15.35%) and fat (5.23%). It was higher with 16%, while ash was higher (3.45%) in batches fed with 12% incorporation. The feed cost was lower at 8% incorporation (734.89Fcfa/kg of fish produced). The incorporation of 8% avocado pulp meal was found to improve the growth of *Clarias jaensis* juveniles and reduce the feed cost. Producers can use spoiled avocados as fish feed to reduce production costs, without negative impact on the final product.

Keywords: *Incorporation, Persea americana, growth, survival, juvenile, Clarias jaensis.*

Introduction

Fish, whether from the fisheries or aquaculture sector, plays a crucial role in improving and securing household food and nutrition in developing countries (Béné et *al.,* 2015). Indeed, fish is an excellent source of protein, micronutrients and polyunsaturated fatty acids (FAO, 2018). Its global consumption person has increased from an average of 9.9 kg in the 1960s to 19.7 kg in 2013, and initial estimates for 2015 point to the crossing of the 20 kg mark (FAO, 2016). In Cameroon, this consumption is estimated at nearly 17.9 kg per person per year, which is an annual demand in tons of nearly 400,000 t/year, mostly met by massive imports of frozen fish of 220,000 t/year, a total national production of fish estimated at nearly 180,000 tons of fish of which less than 0,1% comes from aquaculture (Temegne and Momo, 2019). To overcome this problem, the Cameroonian government has decided to revive aquaculture to meet demand and reduce imports of frozen fish. However, the emergence of the aquaculture sector in Cameroon is confronted with many constraints, of which feeding is one of the main ones, influenced by the low availability and high cost of quality feed inputs to combine optimal growth, fish health and product quality, especially flesh for human consumption (FAO, 2016).

It is well known that in aquaculture, feed represents a large part of the production cost (Gandaho, 2007. However, the use of an inadequate feed can lead to reduced growth but more seriously to nutritional deficiencies or mortality due to increased susceptibility to infectious diseases. Therefore, it is important to assess the nutritional value of alternative feeds for fish based on locally available fruit by-products and waste. Mabuhay in 2018 evaluated the nutrient contribution of plant and fruit wastes as feed additives in aquaculture. The use of plants as an input to fish feed have already been studied extensively, mainly on *Chromolaena odorata* (Boukila *& al.,* 2009) and *Desmodium uncinatum* (Efole *& al.,*2016). However, not all plant components are generally used as feed within the fruit, while some of them, notably avocado (*Persea americana*), end up as waste in post-sale and post-harvest losses to the environment, leading to organic pollution. This waste can potentially be recycled and returned to the food chain by converting it into aquaculture feed. In Cameroon, nearly 30 to 40% of this avocado production is lost post- harvest and post-sale due to the lack of processing and storage units (Ludovic T., 2015), estimated at 200 tons / month by RECOSAF. However, based on the observation that avocado pulp is degraded by catfish and the fact that no study has been published on the use of avocado as an ingredient in the intensive feeding of *Clarias jaensis,* it seemed important and interesting to carry out this work.

Material and Methods

Geographic Location

The study took place between April and June 2019 in the Kanhe-Moyo Integrated Fisheries and Aquaculture Research and Application Farm in Baham, located between 5°17'54"-5°17'57" LN and 10°22'20"- 10°22'31"LE, West Region - Cameroon, the average altitude is 1700 m.

The objective was to evaluate the influence of the incorporation rate of avocado pulp meal (Table 1) on the zootechnical performances, a total of 156 juveniles of *Clarias jaensis* with an average weight of 25.82g ± 7.43g and a size of 15.06±0.4 cm were randomly distributed in the 12 tanks of 40l each, placed in a pond of 80 m^2. The fish were fed for 63 days on four (04) iso-protein feeds with 40% protein (tab.2) incorporated with 0, 8, 12 and

16% of ripe avocado pulp flour. 15 kg of fresh pulp from post-harvest losses on the farm and from post-sale losses at the various avocado depots in Bafoussam were used.

Table 1. Composition in % (DM) of *Persea americana* Pulp

Chemical components	Composition (%DM)
Humidity	81.00
Proteins	1.89
Lipids	75.00
Fibers	8.00
Carbohydrates	2.00
Ca (mg/100g DM)	70.40

12 basins of 0.035m3 perforated with holes of 10cm diameter on both sides were used as infrastructure, mosquito nets to cover the basins, string to hold them together, a Secchi disc of 50cm length, a landing net for control fishing, an ichthyometer, a multiparameter of the brand HANNA Hi 9813-5, an oximeter of the brand MILWAUKEE, an electronic balance of 1g precision was used to take the weight of the juveniles.

Formulation and Preparation of the Feed Used

04 experimental feeds were formulated at 40% crude protein and separated into different treatments according to the incorporation levels (Tab. 2)

Table 2. % Composition of Experimental Diet with Incorporation Level of *Persea americana* Ripe Pulp

Ingredients (%)	**Incorporation levels of ripe avocado pulp powder (%)**			
	0	**8**	**12**	**16**
Fish meal	23.36	23.36	23.36	23.36
Soybean meal	23.36	26.50	28.7	29.31
Cottonseed cake	23,36	23,36	23,36	23,36
Premix	1.00	1.00	1.00	1.00
Wheat bran	13.00	7.40	4.30	1.98
Corn flour	13.00	7.40	4.30	1.98
Persea americana ripe pulp	0.00	8.00	12.00	16.00
Bone meal	2.00	2.00	2.00	2.00
Palm oil	1.00	1.00	1.00	1.00
Total	**100.00**	**100.00**	**100.00**	**100.00**
Analytical composition (%MS)				
Dry matter	90.44	89.12	89.1	88.99
Proteins	39.99	39. 89	39.99	39.76
Fat	15.98	17.15	19.15	21.41
Ash	32.30	24.70	24.70	26.70
Fiber	22.10	23.14	25.45	28.57
Gross energy (kcal/ 100g)	221	295	223	295

Practical Feeding

The raw ingredients were finely ground and sieved through 400 micrometer mesh. In order to determine the amount of fresh pulp to be incorporated in each ration, a traditional process (Fig. 1) was used to condition the fresh pulp and determine its dry matter. After determining the dry matter of the avocado pupa, the pulp harvested from the spoiled ones was then added to the mixture of ingredients in the same proportions as the different incorporations, to which palm oil was added. Water was previously boiled to 2/3 of the amount of food taken, considering that a good part of it would evaporate during boiling, and was then added to form a malleable paste to be transformed into spaghetti through the die of a meat grinder (TC 22SL), it gave filaments of 3 mm in diameter. These filaments were then dried in a storfish electric dryer, broken down to the desired size, bagged and stored until distribution to juveniles.

Collection of spoiled avocados at the market and around the farm.

Experimental Design

12 basins of 35 L of useful volume were installed in triplicates in a random manner in a pond of $80m^{2}$, equipped with a tarpaulin in its base, to prevent infiltration, and each corresponding to a treatment so as to allow water circulation and oxygen diffusion. They are held in place by a string attached to stakes at each end of the pond, posts at each end and floats attached to the basins to allow them to float. They were covered with mosquito netting and above them were

suspended half bottles to serve as feeding points. Subsequently, a total of 156 fish were introduced at a rate of 13 individuals per tank and acclimatised for one week.

Feed Distribution, Growth and Environmental Monitoring

The distribution of the different treatments was done at a frequency of twice a day (06h, 18h) at a rationing rate of 5% of the fishy biomass (photo a). In order to monitor growth and adjust the quantities of feed distributed per period, control fisheries were carried out every 21 days, at the cool hours of the day (6:30 am). All individuals were caught, weighed and then measured individually on a 1g precision scale and an ichthyometer. To monitor the physico-chemical parameters of the environment, the temperature, dissolved oxygen and ph of the water were taken in situ every day (photo c) between 7 and 8 am using a Hanna multi-parameter and a Milwaukee oximeter.

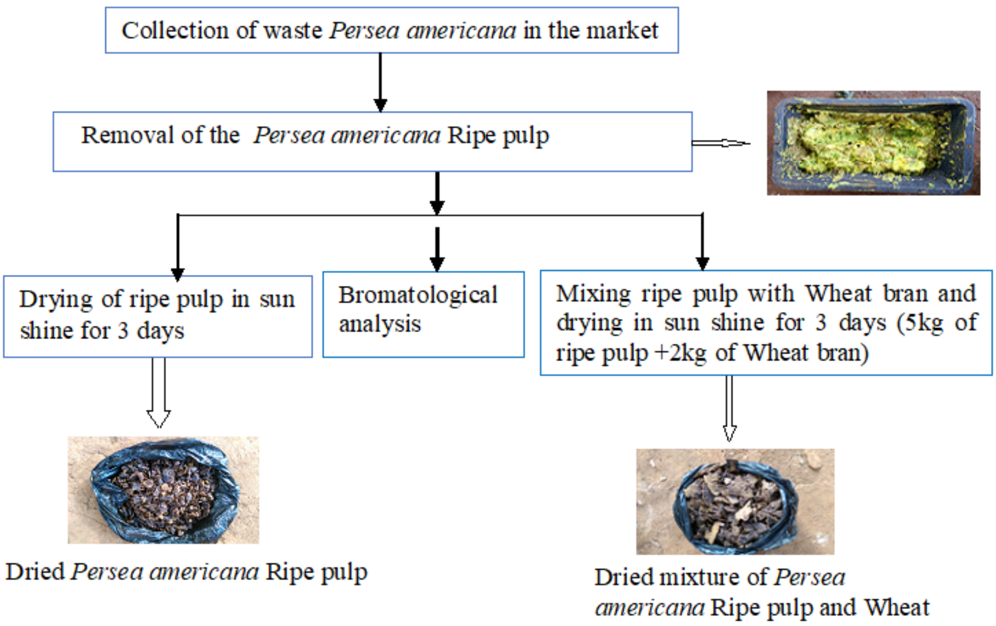

Figure 1. Conditioning Applied to Avocado (*Persea americana*) Pulp

Biochemical Analysis

Samples of two fish were taken randomly at the end of the study for each treatment for analysis at the FASA Nutrition Laboratory of the University of Dschang according to the AOAC (1999) method, with the aim of determining protein, lipid and ash contents by the Kjedhal, Soxhlet and Schiemann method for energy respectively. Similar analyses were also carried out on the experimental foods and on *Persea americana* pulp.

Parameters Studied

- **Survival rate (SR)**

$SR = \left(\frac{Nf}{Ni}\right) x100$ Where Nf =final number of fish and Ni=initial number of fish

- Mean **Weight Gain** (MWG)

$MWG(g) = MWf - MWi$, Where MWf is final mean weight and MWi initial mean weight;

- **Average Daily Weight Gain (ADWG)**

$ADWG(g/d) = \frac{(MWf - MWi)}{t}$, Where MWf=final mean weight and MWi=initial Mean weight and t= duration (d)

- **Specific growth rate (SGR)**

$$SGR(\%\frac{g}{d}) = \frac{(In\ (MWf) - In(MWi))}{\text{t}} x100$$

- **Condition factor (K)**

K (g/cm^3) = W*100/ TL^3 where W = weight (g), TL = total length (cm)

- **Consumption Index** (CI)

$CI = \frac{\text{FD−FR}}{WG}$, where FD=distributed feed and FR=remaining feed or non-consumed feed

Body Characteristics of the Fish Flesh Produced

- **Dry matter (DM)**

The percentage of dry matter is determined by drying the feed and dry fish samples in an oven at 103°C overnight (12 hours) and calculated using the

following formula: $\boldsymbol{DM}(\%) = \frac{\textbf{Pf−Pc}}{\textbf{P0}} \textbf{x } \textbf{100}$ where Pf is Weight of crucible + sample after ovun, Pc is Weight of empty crucible, Po is Weight of sample.

After determination of DM, the sample is placed in a muffle furnace at 500°C for 6 hours for the ash content and the following calculation is made:

$$Ash\ (\%) = \frac{\text{Pf} - \text{Pc}}{Po} x100$$

Where: *Pf* = Weight of crucible + sample after 6 hours in the oven; *Pc* = Weight of empty crucible

Lipids or Fats

The lipid content is determined by the Soxhlet method (AOAC, 1999). This method is based on the solubilisation of lipids in apolar organic solvents (petroleum ether,

chloroform, benzene). In the sample, it is determined by the following relationship:

$$\boldsymbol{Fats}\ (\%\boldsymbol{DM}) = \frac{\textbf{Pf−Po}}{\textbf{mo}} \textbf{ x 100;}$$

Where m_0 = 1g = weight of the sample; P0= weight of sample + cellulose weight of cartridge.

Crude protein

The total nitrogen content is determined by the Kjeldhal method (AOAC, 1990). The nitrogen (N) content is then calculated according to the following formula:

$$\boldsymbol{N}\ (\%\boldsymbol{DM}) = \frac{\textbf{V−Vo x 100 x 0,14 x 10−3}}{\textbf{m x Ve}} \boldsymbol{x}\ \textbf{100} \quad ;$$

Where V= Volume of HCl used for sample titration, V0= Volume of HCl used for the blank titration.

Nutritional retention (NR)

$$NR = \frac{(WfxFfc) - (Wi\ x\ Ifc)}{\text{QFc x Fc}}\ x\ 100$$

Wf = final weight; Wi = initial weight; Ffc = final fish composition; Ifc = initial fish composition; QFc=quantity of food consumed and Fc=food composition

Economic Characteristics

The economic evaluation of the different treatments was carried out on the basis of the cost of food production calculated from the unit price of the ingredients obtained on the local market, with the exception of *Persea americana* pulp, the price of which was estimated from the transport from the market where they were collected to the study farm. The only parameter considered was the consumption index. Thus, the characteristics evaluated were the following:

- Cost of a kg of food (Cf)

$$Cf = \frac{\Sigma\ [\text{quantiy of ingrédient (g) x cost of one kg (FCFA)x 1000}]}{100}$$

- Food cost per kg of fish produced (FCf)

$$CFf = Cf \times IC$$

Statistical Analysis

Growth and biochemical parameters were expressed as mean ± standard deviation and as percentages. An analysis of variance (ANOVA) was used to compare the different treatments and Duncan's test at a 5% threshold to separate the mean in case of significant difference using SPSS 20.0. The curves were made with Microsoft Office Excel 2016.

Results

Survival Rate and Growth Characteristics of *Clarias jaensis* Juveniles as a Function of the *Persea americana* Ripe pulp Meal

The highest values of survival rate (SR) were recorded in treatments receiving 8 and 12% incorporation of *Persea américana* but statistical analysis showed no significant difference ($P > 0.05$). The final average weight (pmf), and weight gain (GP) were significantly higher with the batches receiving 8% compared to the batches receiving 0% and 16%. On the other hand, the condition factor K did not vary much with the level of incorporation. However, the CI recorded a higher value with 8% incorporation.

Table 3. Survival Rate and Growth Characteristics of *Clarias jaensis* Juveniles as a Function of the Level of Incorporation of Ripe *Persea Americana* Pulp Meal in the Feed

Survival Rate and Growth Characteristics	Incorporation levels of avocado ripe pulp meal (%)				P
	0	8	12	16	
SR (%)	98.075 ± 1.15[a]	99.14 ± 0.50[a]	98.29 ± 0.75[a]	93.67 ± 8.47[b]	0.009
MWf (g)	34.70 ± 8.12[b]	40.22 ± 10.5[a]	35.47± 6.38[b]	30.02 ± 8.00[c]	0.000
ADWG (g/d)	0.11 ± 0.42[a]	0.14 ± 0.44[a]	0.12 ± 0.3[a]	0.08 ± 0.22[a]	0.784
SGR (%g/d)	0.34 ± 1.22[a]	0.41 ±1.07[a]	0.39 ± 0.83[a]	0.28 ± 0.77[a]	0.842
CI	1.92 ± 0.09[a]	1.87 ± 0.09[a]	1.90 ± 0.17[a]	2.018 ± 0.17[a]	0.098
K (%g/cm³)	0.68 ± 0.05[a]	0.70 ± 0.09[a]	0.68 ± 0.11[a]	0.68 ± 0.15[a]	0.660

Note: Values are means ± standard deviation of three replicates of basins in each treatment; SR=Survival Rate; MWf=final Mean Weight; ADWG=Average Daily Weight Gain; SGR=Specific Growth Rate; CI= Consumption Index and K= condition factor.

Note: Means on the same line with different letters a, b, c are significantly different ($P<0.05$).

Daily Evolution of the average weight of juveniles of *Clarias jaensis*

Figure 2 illustrates the evolution of the average individual weight of *Clarias jaensis* juveniles as a function of the levels of incorporation of ripe avocado pulp meal during the test.

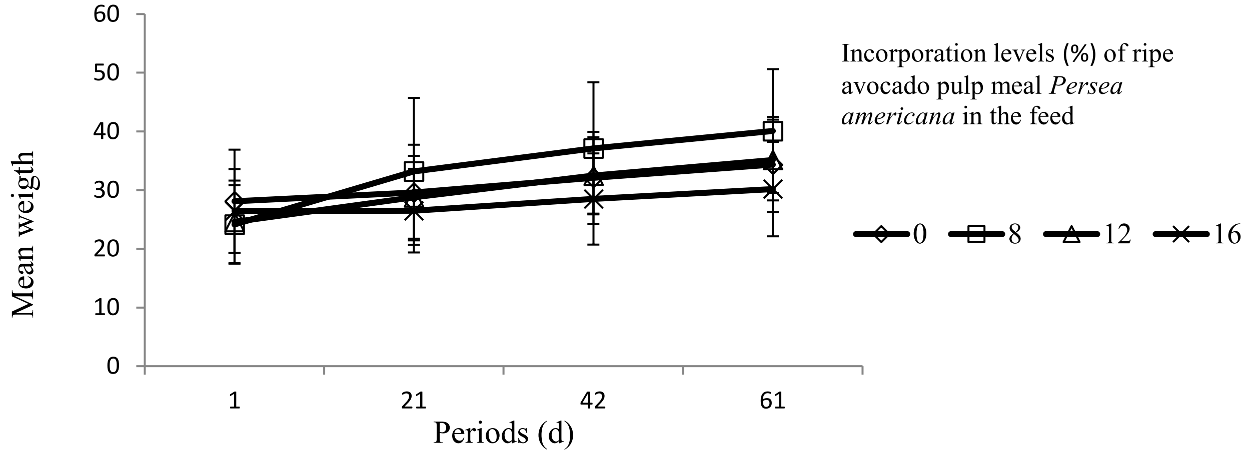

Figure 2. Daily Evolution Mean Weight of *Clarias jaensis* Juveniles in Function of the Incorporation Level of the Ripe Avocado Pulp Meal *Persea americana* in the Feed

The weight increased at all levels of incorporation steadily throughout the trial. This increase was more rapid, first at 8, then at 12 and 0 and finally at 16% incorporation. These results suggest that growth remained lower in the batch receiving 16% incorporation of *Persea americana* pulp flour.

Evolution of the Average Daily Weight Gain in Juveniles of *Clarias jaensis*

Figure 3 shows the evolution of the average daily gain as a function of the level of incorporation of ripe *Persea americana* pulp meal in the feed.

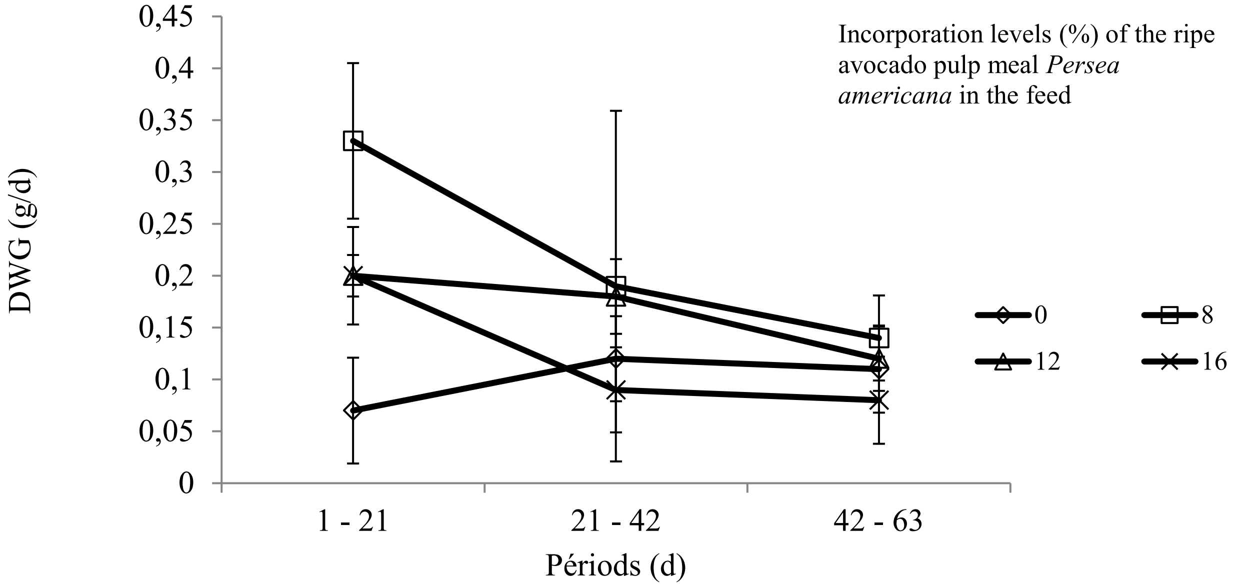

Figure 3. Evolution of the Average Daily Gain in Juvenile *Clarias jaensis* as a Function of the Level of Incorporation of the Ripe Avocado Pulp Meal *Persea americana* in the Feed

It was found that the average daily gain decreased throughout the trial regardless of the level of incorporation. At the end of the experiment, the values obtained were comparable, although the highest without significant difference ($p>0.05$) was observed in the batches fed at 8% incorporation.

Evolution of the Specific Growth Rate of *Clarias jaensis* Juveniles

Figure 4 opposite shows that the evolution of the specific growth rate of juveniles varied with the level of incorporation.

The evolution varied with the levels of incorporation, as shown in figure 4. Between the 1st catch (21) and the 2nd catch (42), there was a slight increase with all levels of incorporation, followed by a slight decrease until the end of the trial. However, the lowest values without significant difference with the other incorporation levels ($p>0.05$) were obtained with 16% incorporation of *Persea americana* pulp flour in the feed.

Daily Evolution of the Condition Factor K of Juveniles of *Clarias jaensis*

Figure 5 shows the evolution of the K-factor as a function of the level of incorporation.

The condition factor K varied little regardless of the level of incorporation of *Persea americana* pulp. At the end of the trial, no significant difference was found ($P>0.05$) between incorporation levels.

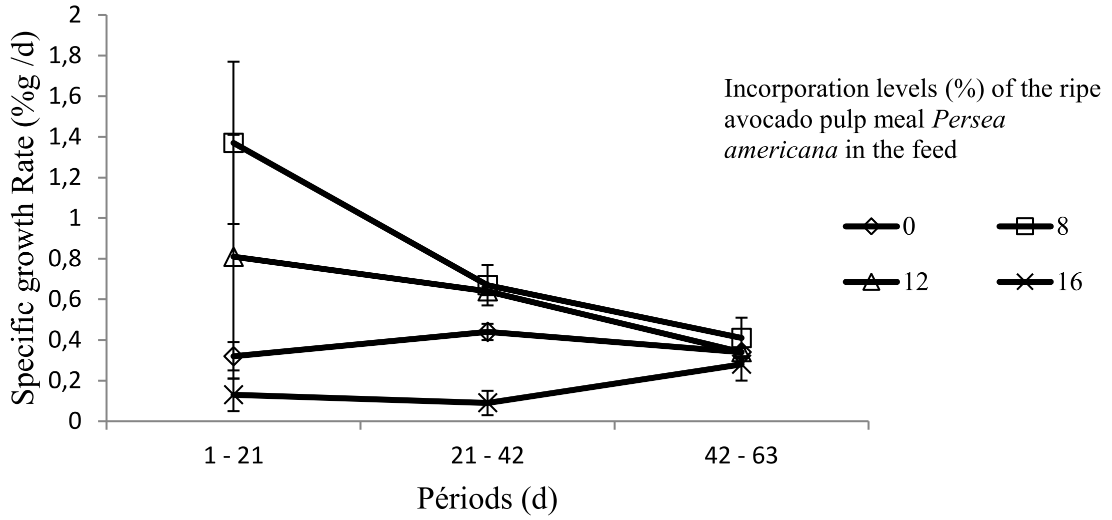

Figure 4. Evolution of the Specific Growth Rate in *Clarias jaensis* Juveniles as a Function of the Level of Incorporation of the Ripe Avocado Pulp Flour *Persea americana* in the Feed

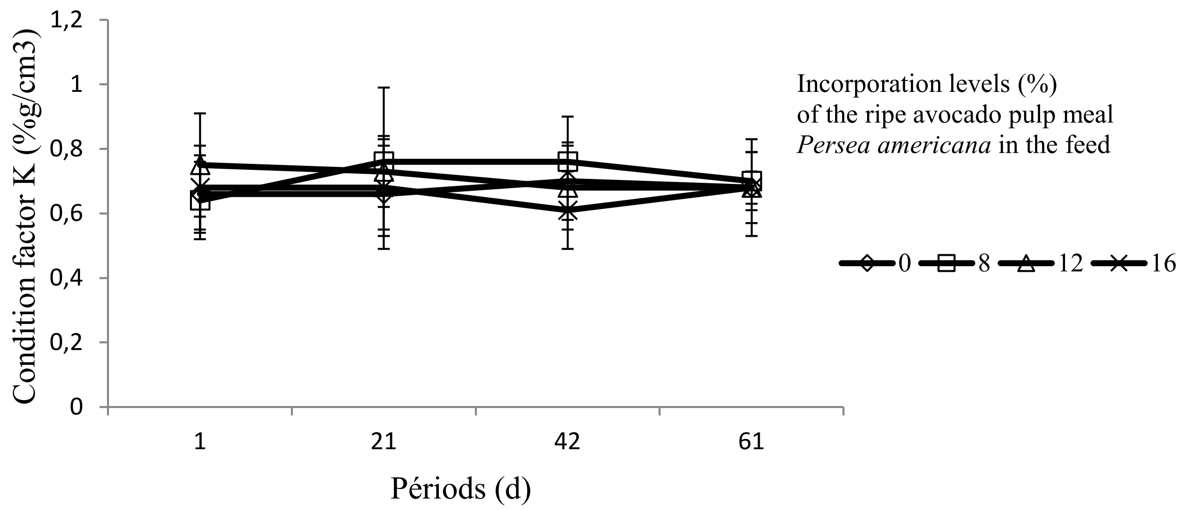

Figure 5. Daily Evolution of the Condition Factor K in Juveniles as a Function of the Level of Incorporation of *Persea americana* Pulp Meal

Body Characteristics of *Clarias jaensis* Juveniles According to Incorporation Levels

Biochemical analysis of juveniles

They show that the relative water content of the fish at the end of the experiment decreased with increasing lipid in all diets compared to the initial sample. While, protein and ash content increased but no significant difference ($p>0.05$) was found. Regarding lipid content, the results show that fish receiving 0 and 8% incorporation had the lowest levels compared to those receiving 12 and 16% incorporation of pulp meal which appeared to be the fattest at the end of the experiment than at the beginning.

Table 4. Body Composition of *Clarias jaensis* Juveniles as a Function of the Level of Incorporation of *Persea américana* Avocado Pulp Meal in the Feed

Body fish composition (%)		**Incorporation levels of ripe avocado pulp meal (%)**				
	Initial	0	8	12	16	p
Water	79.34±0.00[a]	79.14±0.00[a]	77.36±0.00[a]	77.02±0.00[a]	76.13±0.00[a]	0.55
Dry matter	20.66±0.00[a]	20.86±0.00[a]	22.64±0.00[a]	22.98±0.00[a]	23.87±0.00[a]	0.98
Crude Proteins	14.34±1.03[a]	14.85±0.05[a]	14.93±0.60[a]	14.61±0.00[a]	15.35±0.00[a]	0.98
FAD	2.45±0.52[a]	2.66±1.49[a]	4.20±0.00[a]	4.90±0.00[a]	5.23±0.00[a]	0.98
Ashes	3.37±0.36[a]	3.3 ± 1.08[a]	3.42±0.65[a]	3.45±0.03[a]	3.13±0.25[a]	0.52

Note: Means on the same line with letter a are not significantly different ($P<0.05$).

Nutrient retention in juvenile *Clarias jaensis in* relation to incorporation levels

Nutrient retention is illustrated in Figure 6 below.

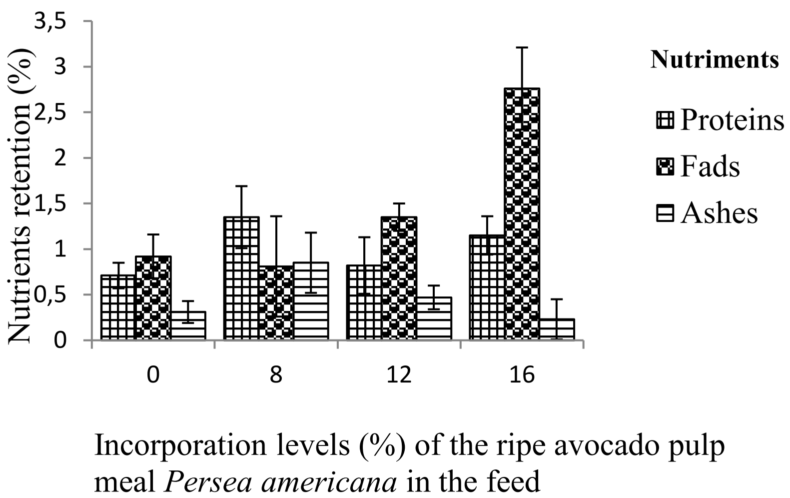

Figure 6. Variation in Nutrient Retention in Juveniles of *Clarias jaensis* Depending on the Level of Incorporation of the Ripe Persea Pulp Powder Americana in Feed (%)

It was found that protein retention was highest with 8 and 16% incorporation of avocado pulp flour, and lowest with 0 and 12% incorporation. The highest value of lipid retention was obtained with 16% pulp flour incorporation followed by that with 12%. The ash retentions varied little, although the highest was obtained with 8% incorporation.

Estimation of the cost price of one kilogram of feed and production of one kilogram of *Clarias jaensis* juveniles according to the level of incorporation

This table 5 summarises the feed cost of one kg of feed and one kg of *Clarias jaensis as a* function of the level of incorporation of *Persea américana* avocado pulp meal.

Table 5. Food Cost of Producing One Kilogram of Fish According to Incorporation Level

Incorporation levels of ripe avocado pulp powder(%)	**Cost of kg of feed (Fcfa)**	**Consumption Index**	**Cost of feed / kg fish produced (Fcfa)**
0	394.76	1.92	757.94
8	392.99	1.87	734.89

12	393.81	1.98	779.74
16	390.45	2.02	788. 71

The results show that the cost of feed was lower at 8% incorporation

Discussion

The highest survival rate of *Clarias jaensis* juveniles was obtained with 8% incorporation. The values obtained at the end of the trial are comparable to those (94.87 to 100%) reported by Ekoué (2013) for *Clarias gariepinus* juveniles fed with Néré almond meal and soybean meal.

The highest average final weight recorded at the end of the trial was noted with 8% incorporation of *Persea américana* pulp meal, relatively lower compared to that obtained by Efole et *al,* 2016 (84.8g) during 120 days with 10% incorporation of *Desmodium uncinatum* in *Clarias jaensis*. This difference could be explained by exogenous factors such as feed, rearing infrastructure, and endogenous factors namely the size and strain of fish which were different. The average daily gain, varied downwards with the levels of incorporation of *Persea americana*. They remain lower than those obtained by Azaza & *al* in 2006 on tilapia fed with tomato meal incorporated in the feed under similar experimental conditions. The highest weight gains were obtained with the batches receiving 8 and 12% pulp incorporation. The differences in growth observed at the end of the trial between these batches could be related to a difference in digestibility and assimilation which are a function of the nature of the ingredients used as pointed out by Burel et *al* (2000).

The specific growth rates (SGR) obtained at the end of the trial remain higher than those obtained by Hoffman et *al.* 1997 (0.04 to 0.18%/d), yet lower than those (1.9 and 3.4%/d) obtained by Ekoué in 2013 (3.60%/d) with juveniles of the same species. However, these TCS values are in the same range as those obtained by Sotolu in 2010 (from 0.23 to 0.46%/d) in *Clarias gariepinus* with *Leucaena leucocephala* incorporation levels. The low values of this assay could be explained by the density used in the assay, and by the very high presence of fibre in the experimental feed as determined by biochemical analysis, tannins and saponins present in the pulp, as Hilton et *al* (1983) showed that a diet containing more than 10% fibre alters the digestible enzyme activity by absorption and immobilisation phenomena by binding to the various nutrients. The condition factor K varied very little with the levels of incorporation. Indeed, the values obtained in *Clarias jaensis* during the test are comparable (P >0.05) to those reported by Ekoué (2013) (0.6 to 0.74) in *Clarias gariepinus*. Consumption index varied according to the level of incorporation of *Persea americana*. They are comparable to those obtained by Azaza et *al.* in 2005 (1.51 to 2.11). The CI values could be explained by two factors: the unfertilized state of the ponds, which eliminates the consumption of natural feed, and the presence of anti-nutritional factors (tannin content of the pulp), which, according to Medale and Kaushik (2009), can reduce the palatability and nutritional value of the feed.

The results of the analysis of the protein content in the fish flesh varied between treatments. These values were lower than 20.29% (Francis *& al.,* 2001) obtained with *C. gariepinus* and 34.16% (Efole & *al.,* 2016) on juveniles of the same species. This could be due to the high fiber content of the experimental feed. Because Adelakun *& al.* (2014) showed that the high fiber content of the feed interferes with the processing of the feed in the fish gut, thus reducing the digestibility of the feed and contributing to protein loss. In contrast to the water content which decreased with the increase in fat.

The prices of the ingredients were those on the market at the time of the test, while the price of the avocado was determined by reference to the cost of transport. Feed costs varied with the levels of incorporation, however, they were lower than those obtained by Efole et *al.* in 2012 with *desmodium* incorporations (422.56 - 430.5 FCFA), and comparable to those obtained by Kemegne, 2004 with incorporation rates (R0, R10, R15) of *Chromolaena odorata* whose values were 356.7;

381.26and 375 FCFA. Similarly, the cost of producing 1 kg of fish was low for the 8% incorporation and high for the 12% incorporation. The results obtained in this trial show that, under the experimental conditions, the incorporation of 8% of *Persea americana* pulp has the lowest feed cost, which indicates that it is the most economically efficient.

Conclusion

At the end of this trial, which focused on the effect of the level of incorporation of avocado pulp flour *Persea americana* on the zootechnical performance of *Clarias jaensis* juveniles, and in view of the economic profitability analyses, the results obtained showed that the incorporation of this agricultural by-product at a rate of 8% leads to a reduction in the financial charges linked to the cost of production of a kilogram of fish without any prejudice to the growth of fish. Therefore, the incorporation of avocado pulp flour is possible and advantageous and allows for the valorisation of this locally available by- product.

Conflict of Interests

No conflict of interest.

References

Adelakun, K.M., Mustapha, M.K., Maradun, H.F., & Amali RP. (2014). Nutrient quality of African catfish (*Clarias Gariepinus*, burchell 1822): fed Cissus Populnea root meal based diet as soybean meal replacer. *Science-Africa Journal of Scientific Issues, Research and Essays, 2*(5), 218-221.

AOAC (Association of Official Analytical Chemist). (1999). *Official methods analysis of the association of Official Analytical Chemist.* In: Cunniff P.(Ed), 16TH edition. AOAC, International, Washington, DC, 1141

Azaza Mohammed, S., Mensi, F., Imourou Toko, I., Addelmouheh, B., Brini, B., & Kraïem, M. (2006). Effects of incorporating tomato flour in the diet of Nile tilapia (*Oreochromis niloticus*) L., 1758 reared in geothermal waters of southern Tunisia. I*nstitut national des sciences et technologies de la mer 2025 Salammbô, 33*, 47-55.

Béné, C., Barange, M., Subasinghe, R., Gorka, P.-A., Hemre, G.-I. & Williams, M. (2015). Feeding 9 billion by 2050 – Putting fish back on the menu. *Food Security, 7.* https://doi.org/10.1007/s12571-015-0427-z

Burel, C., Boujard, T., Tulli, F., & Kaushik, S.J. (2000). Digestibility of extruded peas, extruded lupin, and rapeseed meal in rainbow trout (Oncorhynchus mykiss) and turbot (Psetta maxima). *Aquaculture, 188*, 285-298. https://doi.org/10.1016/S0044-8486%2800%2900337-9

Efole, E.T., Tchouante, T.C.G., Miegoue, E., Tsoupou, K.S.G., Nana, T. A., Tedonkeng, F., Pouomogne V., Mikolasek O. & Tcthoumboue J. (2016). *Effect of Level of Desmodium Uncinatumincorporation in the Diet on Growth Performance of Clarias jaensis (Boulenger, 1909) in the Highlands of west Cameroon.* Department of aquaculture, Institute for Agronomic Research for Development, Station of Foumban, Cameroon, ISEM, CIRAD, University of Montpellier, France.

Ekoué, C.A. (2013). Effects of substituting fish meal with cowpea (*Parkia biglobosa*) and soybean meal (Glycine maxima) on the growth and survival of juveniles of *Clarias gariepinus* (Burchell, 1822).

FAO. (2016). State of World Fisheries and Aquaculture, Contributing to Food Security and Nutrition for All, Rome. Retrieved from https://www.fao.org/3/i5555e/i5555e.pdf

FAO. (2018) State of World Fisheries and Aquaculture: Achieving the Sustainable Development Goals. Rome. Retrieved from https://www.fao.org/family-farming/detail/en/c/1145050/

Gandaho P.S. (2007). *Etude des performances de croissance des juvéniles de Clarias gariepinus (Burchell, 1822) nourrisées à base de Moringa oleifera et de sous-produits locaux.* Dissertation presented in view of obtaining the degree of Doctor of Science.

Hilton, J.W., Atkinson, J.L. & Slinger, S.J. (1983). Effect of Increased Dietary Fiber on the Growth of Rainbow Trout (*Salmo gairdneri*). *Canadian Journal of Fisheries and Aquatic Sciences, 40*(1), 81-85. https://doi.org/10.1139/f83-012

Hoffman, L.C., Prinsloo, J.F., & Rukan, G. (1997). Partial replacement of fish meal with either soybean meal, brewers yeast or tomato meal in the diets of African sharptooth catfish Clarias gariepinus. *Water SA, 23*, 181-186.

Ludovic, T. (2016). *Agriculture Biologique et Sécurité Alimentaire en Afrique Sub-Saharienne Rapport Cameroun 2016*. Ateliers ABASS Diversités des Agriculture Biologiques en Afrique Subsaharienne. Retrieved from https://agritrop.cirad.fr/583812/1/Rapport-Abass-Cameroun%2BFin.pdf

Medale, F. & Kaushik, S. (2009). Protein sources in feed for farmed fish. *Cahiers Agricultures, 18*(2), 103-111. https://doi.org/10.1684/agr.2009.0279

Adeniyi, O.V., Olaifa, F.E. & Emikpe, B.O. (2018). Growth Performance and Nutrient Digestibility of Clarias gariepinus (Burchell 1822) Fed Diets Fortified with Tamarindus indica Pulp and Leaf Meal. https://doi.org/10.33997/j.afs.2018.31.1.002

Noubayo, Y.J. (2004). *Effect of the incorporation of avocado pulp in the diet of Clarias gariepinus on its survival and growth performance at the IRAD fish farming research station of FOUMBAN.* Dissertation, FASA, Dschang.

Shiau, S.Y., Chuang, J.L., Sun, C.L. (1987). Inclusion of soybean meal in Tilapia (*Oreochromis niloticus*) diets at two protein levels. *Aquaculture, 65,* 251-261. https://doi.org/10.1016/0044-8486(87)90238-9

Sotolu, A.O. (2010). Growth Performance of *Clarias gariepinus* (Burchell, 1822). Fed Varying Inclusions of *Leucaena leucocephala* Seed meal. *Tropicultura, 28*(3), 168-172.

Temegne, N.C. & Momo, N.J. (2019). Review on Aquaculture Research in Cameroon: Fish Farming. *International Journal of Oceanography & Aquaculture*. https://doi.org/10.23880/ijoac-16000170